FORM PTO-1390 (Rev 5-93) U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371

ATTORNEY'S DOCKET NUMBER: **ROCKCO P39AUS**

U.S. APPLICATION NO. (If known, see 37 CFR 1.5): **09/171583**

INTERNATIONAL APPLICATION NO.	INTERNATIONAL FILING DATE	PRIORITY DATE CLAIMED
PCT/GB97/01121	**23 April 1997**	**23 April 1996**

TITLE OF INVENTION: **LIGHT EMITTING DEVICE AND ARRAYS THEREOF**

APPLICANT(S) FOR DO/EO/US: **John William BAILLIE-HAMILTON**

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ■ This is a FIRST submission of items concerning a filing under 35 U.S.C. 371.

2. ☐ This is a SECOND or SUBSEQUENT submission of items concerning a filing under 35 U.S.C. 371.

3. ■ This express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39(1).

4. ■ A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.

5. ■ A copy of the International Application as filed (35 U.S.C. 371(c)(2))
   a. ☐ is transmitted herewith (required only if not transmitted by the International Bureau).
   b. ■ has been transmitted by the International Bureau. (PCT/IB/308 mailed October 30, 1997)
   c. ☐ is not required, as the application was filed in the Untied States Receiving Office (RO/US)

6. ☐ A translation of the International Application into English (35 U.S.C. 371(c)(2)) is attached.

7. ■ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))
   a. ☐ are transmitted herewith (required only if not transmitted by the International Bureau).
   b. ☐ have been transmitted by the International Bureau.
   c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
   d. ■ have not been made and will not be made.

8. ☐ A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).

9. ■ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)) (unsigned).

10. ☐ A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11. to 16. below concern other document(s) or information included:

11. ☐ An Information Disclosure Statement under 37 CFR 1.97 and 1.98 with PTO FORM 1449.

12. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.

13. ■ A FIRST preliminary amendment.
    ☐ A SECOND or SUBSEQUENT preliminary amendment.

14. ☐ A substitute specification.

15. ☐ A change of power of attorney and/or address letter.

16. ■ Other items or information:

☐ Preliminary Examination Report	■ International Publ. No. WO 97/40520(Face page only)
☐ Annexes to Pre. Ex. Rep.	■ Copy of Request
■ International Search Report	■ 6 sheets of formal drawings
☐ ___ copies of citations	☐ Verified Statement Claiming Small Entity Status
☐ Copy of Notification of File Missing Parts	■ Abstract
■ Form PCT/IB/308	☐

CERTIFICATION UNDER 37 CFR 1.10

I hereby certify that this Transmittal Letter and the papers indicated as being transmitted therewith is being deposited with the United States Postal Service on this date October 21, 1998 in an envelope as "Express Mail Post Office to Addressee" Mailing Label Number EL012165174US addressed to the: Commissioner of Patents and Trademarks, Washington, D.C. 20231.

Michael J. Bujold
(typed or printed name of person mailing paper)

Michael J. Bujold
(signature of person mailing paper)

17. ■ The following fees are submitted:	CALCULATIONS	PTO USE ONLY
Basic National Fee (37 CFR 1.492(a)(1)-(5)):		
Search Report has been prepared by the EPO or JPO $930.00		
International preliminary examination fee paid to USPTO (37 CFR 1.482) $720.00		
No international preliminary examination fee paid to USPTO (37 CFR 1.482) but international search fee paid to USPTO (37 CFR 1.445(a)(2)). $790.00		
Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO $1,070.00		
International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(1)-(4) $98.00		
ENTER APPROPRIATE BASIC FEE AMOUNT =	$ 930	
Surcharge of $130.00 for furnishing the oath or declaration later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(e)).	$ -0-	

Claims	Number Filed	Number Extra	Rate		
Total Claims	35 - 20 =	15	x $22.00	$ 330	
Independent Claims	1 - 3 =	0	x $82.00	$ -0-	
Multiple dependent claim(s) (if applicable)			+ $270.00	$ -0-	
			TOTAL OF ABOVE CALCULATIONS =	$1260	
Reduction by 1/2 for filing by small entity, if applicable. Verified Small Entity statement must also be filed. (Note 37 CFR 1.9, 1.27, 1.28).				$1260	
			SUBTOTAL =	$1260	
Processing fee of $130.00 for furnishing the English translation later the ☐ 20 ☐30 months from the earliest claimed priority date (37 CFR 1.492(f)). +				$ -0-	
			TOTAL NATIONAL FEE =	$1260	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). $40.00 per property +				$ -0-	
			TOTAL FEES ENCLOSED =	$1260	
				Amount to be: refunded	$
				charged	$

a. ■ A check in the amount of $ 1260 to cover the above fees is enclosed.

b. ☐ Please charge my Deposit Account No. 04-0213 in the amount of $___ to cover the above fees.
A duplicate copy of this sheet is enclosed.

c. ■ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 04-0213. A duplicate copy of this sheet is enclosed.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:

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10/21/98 PATENT APPLICATION

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of	:	John William BAILLIE-HAMILTON
Serial no.	:	
Filed	:	with an effective filing date of
For	:	LIGHT EMITTING DEVICE AND ARRAYS THEREOF
Docket	:	ROCKCO P39AUS

The Commissioner of Patents and Trademarks
Washington, D.C. 20231

PRELIMINARY AMENDMENT

Dear Sir:

By way of preliminary amendment, please amend the above identified application as set forth below.

In the Claims:

Please cancel original claims 1 - 37, as well as any Chapter II amended claims, in favor of new claims 38 - 72 as follows.

38. A light outputting device comprising:

a containment for housing an element for emitting light, the containment having a longitudinal axis and a width transverse of the longitudinal axis;

a light conducting element extending axially from the containment and having an axial length substantially greater than the transverse width; the light conducting element being aligned co-axially with the element for emitting light in the containment by means of the containment or an extension thereof; the width of the light conducting element being similar to the transverse width; and the light conducting element having a light input region whereby light generated by the element is enabled to pass axially into the light conducting element.

39. The light outputting device according to claim 38, wherein the containment or an extension thereof serves to locate the element for emitting light closer to the light input region of the, or each, light conducting element than to the major part of the containment remote from the light input region or regions.

40. The light outputting device according to claim 38, further incorporating a reflector

located relative to: the element for emitting light and the light conducting element so as to reflect light from the element for emitting light axially into the light conducting element by way of its associated light input region.

41. The light outputting device according to claim 38, further incorporating a refractor located relative to: the element for emitting light and the light conducting element so as to refract light from the element for emitting light axially into the light conducting element by way of its associated light input region.

42. The light outputting device according to claim 38, wherein the containment is substantially opaque such that light can only pass out of the containment from the element for emitting light by way of the light conducting element.

43. The light outputting device according to claim 38, further incorporating heat transfer means in intimate contact with, or forming an integral part of, the containment whereby heat generated by the element for emitting light is dissipated.

44. The light outputting device according to claim 38, further incorporating heat transfer means in intimate contact with, or forming an integral part of the light conducting element whereby heat generated by the element for emitting light is dissipated.

45. The light outputting device according to claim 38, wherein the containment serves to define a plenum about the element for emitting light whereby a vacuum or ain inert gas or a mixture of gases to be maintained by means of the plenum about the element for emitting.

46. The light outputting device according to claim 38, wherein the element for emitting light is contained in an envelope within the containment and the envelope serves to define a plenum about the element for emitting light whereby a vacuum or an inert gas or a mixture of gases to be maintained by means of the envelope about the element for emitting light.

47. The light outputting device according to claim 38, further incorporating means for varying the color of light output by the device.

48. The light outputting device according to claim 38, wherein the element for emitting light comprises more than one light emitter so that the element for emitting light can be used to

emit more than one light wavelength.

49. The light outputting device according to claim 38, wherein the containment serves to provide location means for the device adapted for complementary engagement with an external device whereby the device can be demountably attached by means of the light conducting element or an extension thereof to a further light conducting path in a predetermined position relative to a path datum.

50. The light outputting device according to claim 38, wherein the containment comprises a housing defining a passage in which the light conducting element is located, the passage has an inner end located within the containment service as a wall of a chamber within the containment; and the chamber serves to locate the element for emitting light.

51. The light outputting device according to claim 50, wherein the housing is opaque.

52. The light outputting device according to claim 50, wherein the chamber serves to house, or has a boundary region serving to define, means for reflecting or refracting light emitted by the element for emitting light axially into the light conducting element by way of its associated light input region.

53. The light outputting device according to claim 50, wherein the containment incorporates integral fins or has in good thermal exchange contact with a member incorporating fins; and the fins serve to radiate or otherwise dissipate heat generated by the element for emitting light and transferred to the fins by way of the containment.

54. The light outputting device according to claim 50, wherein the containment includes a further passage whereby the chamber can be communicated with from outside the device to provide for one of varying the pressure in the chamber and supplying the chamber with a one of gas and vapor.

55. The light outputting device according to claim 50, wherein the containment comprises two parts demountably coupled to one another so that when uncoupled form one another the two uncoupled parts expose the interior of the chamber.

56. The light outputting device according to claim 55, wherein the two parts of the

containment each provide or contain a path of electrically conducting material and when assembled the two paths are: electrically insulated from one another and coupled to the element for emitting light to enable electrical power to be supplied to the element.

57. The light outputting device according to claim 50, wherein the containment includes a further passage for a conducting means for supplying electrical power to the element for emitting light.

58. The light outputting device according to claim 57, wherein the further passage can extend one of axially along and radially from the device.

59. The light outputting device according to claim 38, wherein the element for emitting light comprises one or more of the following:

a resistive filament;

an arc;

a discharge device;

a solid state emitter (PN junction); and

a coherent light source with means for light stimulation and amplification.

60. The light outputting device according to claim 38, wherein light conducting element is of fused quartz or other glass like material.

61. The light outputting device according to claim 38, wherein the containment is of fused quartz or other glass like material.

62. A method of fabricating a light outputting device having a containment for housing an element for emitting light, the containment having a longitudinal axis and a width transverse of the longitudinal axis; a light conducting element extending axially from the containment and having an axial length substantially greater than the transverse width; the light conducting element being aligned co-axially with the element for emitting light in the containment by means of the containment or an extension thereof; the width of the light conducting element being similar to the transverse width; and the light conducting element having a light input region whereby light generated by the element is enabled to pass axially into the light conducting

element, wherein the steps of providing the light conducting element in the form of a longitudinal member with end faces and an outer surface apart from the end faces; locating around the light conducting element a sleeve member of greater length than the light conducting element with a first end of the light conducting element at or near one end of the sleeve so as to leave a length of sleeve projecting beyond the opposite end of the light conducting element the first end; the opposite end of the light conducting element to the firs end forming, at least in part, the light input region; causing the sleeve member to be contiguously juxtaposed with the outer surface of the light conducting element; locating the element for emitting light in the length of sleeve projecting beyond the opposite end; deforming the length of sleeve so as to form together with the light input region of the light conducting element the containment for the element for emitting light; and sealing the deformed length of tube to caus the containment to form a gas tight enclosure for the element for emitting light.

63. A method of fabricating a light outputting device according to claim 62, wherein the sleeve is of a similar material to the light conducting member and the step of causing the sleeve member to be contiguously juxtaposed with the outer surface of the light conducting element comprises a fusing operation.

64. A method of manufacturing a light outputting device according to claim 62, wherein the sleeve is of a translucent or opaque material having a thermal coefficient of expansion comparable with that of the light conducting member.

65. A method of manufacturing a light outputting device according to claim 62, wherein the step of locating the element for emitting light in the length of sleeve projecting beyond the opposite end includes locating conductors for supplying energy to the element.

66. A method of manufacturing a light outputting device according to claim 62, wherein the step of locating the element for emitting light in the length of sleeve projecting beyond the opposite end includes locating a mirror element for reflecting light generated by the element for emitting light to enable the mirror element to be enclosed with the element for emitting light in the containment prior to the deforming and sealing steps.

67. A method of manufacturing a light outputting device according to claim 62, wherein the step of locating the element for emitting light in the length of sleeve projecting beyond the opposite end includes locating a lens element for refracting light generated by the element for emitting light to enable the lens element to be enclosed with the element for emitting light in the containment prior to the deforming and sealing steps.

68. The array comprising at least two light outputting device devices, according to claim 38 or fabricated by means of a method according to claim 62 and a light guide array linking the or at least one light conducting element to a light output location remote from at lease one device.

69. The array according to claim 68 wherein at least one of the devices is coupled to a heat exchange means whereby heat generated by the device is dissipated such as by natural or forced convection utilizing gas or liquid coolant.

70. The array according to claim 68, further incorporating in the light guide array or the light output location means for varying the color of light originating from at least one of the devices.

71. The array according to claim 70, wherein at least one of the devices is demountably attached to the array and a magazine of replacement devices is located for the demountably attached device to enable the demountably attached device to be readily removed and replaced by a replacement device from the magazine thereof.

72. The array comprising at least two devices according to claim 38.

ght in the containment prior to the deforming and sealing steps.

REMARKS

Please enter the above before consideration of this application. With respect to the above newly entered claims, please note that the subject matter of the Chapter II amended claims is editorially revised and rewritten to bring that subject matter into conformity with the United States claim format.

In the event that there are any fee deficiencies or additional fees are payable, please charge the same or credit any overpayment to our Deposit Account (Account No. 04-0213).

Respectfully submitted,

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ABSTRACT

A light outputting device comprises; a containment (14) for housing an element for emitting light (11); at least one axially extending light conducting element (13) having an axial length substantially greater than its width transverse the axis; the light conducting element (13) being aligned axially with the element for emitting light (11) by means of the containment (14) or an extension thereof; the, or each, light conducting element (13) having a light input region such as an end face whereby light generated by the element for emitting light (11) is caused to pass axially into the or each light conducting element (13) by way of its associated light input region. Typically the axial length of the light conducting element (13) is at least three times its width transverse the axis. The containment (14) or an extension thereof serves to locate the element for emitting light (11) closer to the light input region of the, or each, light conducting element (13) than to the major part of the containment (14) remote from the light input region or regions.

LIGHT EMITTING DEVICE AND ARRAYS THEREOF

TECHNICAL FIELD

This invention relates to a light emitting device and arrays thereof. The term 'light' is used in this context to include any form of electromagnetic energy where a need exists to generate it at one location for transmission and utilisation at a further location

BACKGROUND ART

Light conducting elements, for example fibre optics, are a well known means of conducting light from a remote source to a desired destination. State of the art fibre optic cables allow relatively large amounts of energy to be transported through relatively small fibres that are flexible, strong, and water resistant. However inputting light energy into relatively small fibres from existing light sources can be expensive as the light sources were not necessarily originally designed for this purpose.

Most light emitting devices consist of an element for emitting light such as a filament surrounded by a vacuum or a gas or gas mixture or an arc contained in a transparent housing. Alternative types of light emitting device are a light emitting diode surrounded by a solid transparent material. Light emitted from the source radiates outward and can be reflected or concentrated by external mirrors and/or lenses in the correct direction and at the required concentration. However suitable lenses and/or mirrors have to be accurately manufactured and are relatively expensive. In use they tend to absorb the energy that is being produced. Due to manufacturing limitations the lens and/or mirror can fail to be an optimised configuration to refract/reflect the light from the source. When otherwise appropriately manufactured by existing techniques such mirrors and/or lenses fail to control the light sufficiently.

Light conducting fibres have a limited acceptance angle which means that unless the directed light is presented to the conducting element at the maximum angle or less the light is not conducted. Also every occurrence of reflection and/or lens

transmission can absorb or scatter between 10 and 30% of the original light. If we add to these losses from absorbtion and transmission Further losses can be added to those of absorbtion and transmission including: those from reflector shape and size; from surface input into the fibre; and through the bulb containment housing. When all these losses are added together there is left a relatively small balance from the transmitted original light.

In order to overcome such losses many current designs utilise brighter and larger light sources. This comes at a price because apart from light such sources produce large amounts of heat which combined with bad directional control can lead to overheating of the bulb and the light conducting fibres. This leads to a requirement for an external fan or other cooling device which adds cost and bulk and an overall increase in energy required by the whole process.

These factors all limit the commercial applications for light conducting elements as the commercial cost outweighs the usefulness of the product. Alternatively the size of the device and/or its energy requirements exceed those of components available to product designers.

DISCLOSURE OF INVENTION

According to a first aspect of the present invention there is provided a light outputting device comprising:

a containment for housing an element for emitting light;

at least one axially extending light conducting element having an axial length substantially greater than its width transverse the axis; the light conducting element being aligned axially with the element for emitting light by means of the containment or an extension thereof; the, or each, light conducting element having a light input region such as an end face whereby light generated by the element for emitting light is caused to pass axially into the or each light conducting element by way of its associated light input region. Typically the axial length of the light conducting element is at least three times its width transverse the axis.

According to a first preferred version of the first aspect of the present invention the

containment or an extension thereof serves to locate the element for emitting light closer to the light input region of the, or each, light conducting element than to the major part of the containment remote from the light input region or regions.

According to a second preferred version of the first aspect of the present invention or the first preferred version thereof the containment incorporates a reflector located relative to:

the element for emitting light and

the, or at least one, light conducting element

so as to reflect light from the element for emitting light into the, or at least one, light input region of the light conducting element.

According to a third preferred version of the first aspect pf the present invention or any preceding preferred version thereof the containment incorporates a refractor located relative to:

the element for emitting light and

the, or at least one, light conducting element

so as to refract light from the element for emitting light into the, or at least one, light input region of the conducting element.

According to a fourth preferred version of the first aspect of the present invention or any preceding preferred version thereof the containment is substantially opaque and light can only pass out of the containment from the element for emitting light by way of the, or at least one, light conducting element.

According to a fifth preferred version of the first aspect of the present invention or any preceding preferred version thereof there is provided heat transfer means such as a heat sink in intimate contact with, or forming an integral part of, the containment whereby heat generated by the element for emitting light can be dissipated.

According to a sixth preferred version of the first aspect of the present invention or any preceding preferred version thereof there is provided heat transfer means such as a heat sink in intimate contact with, or forming an integral part of the, or at least

one, light conducting element whereby heat generated by the element for emitting light can be dissipated.

According to a seventh preferred version of the first aspect of the present invention or any preceding preferred version thereof the containment serves to define a plenum about the element for emitting light whereby a vacuum or an inert gas or a mixture of gases to be maintained by means of the plenum about the element for emitting light.

According to an eighth preferred version of the first aspect of the present invention or any preceding preferred version thereof wherein the element for emitting light is contained in an envelope within the containment and the envelope serves to define a plenum about the element for emitting light whereby a vacuum or an inert gas or a mixture of gases to be maintained by means of the envelope about the element for emitting light.

According to a ninth preferred version of the first aspect of the present invention or any preceding version thereof there are provided means for varying the colour of light output by the device.

According to a tenth preferred version of the first aspect of the present invention or any preceding preferred version thereof the element for emitting light comprises more than one light emitter so that the element for emitting light can be used to emit more than one light wavelength.

According to an eleventh preferred version of the first aspect of the present invention or any preceding preferred version thereof the containment serves to provide a location means for the device adapted for complementary engagement with an external device whereby the device can be demountably attached by means of the light conducting element or an extension thereof to a further light conducting path in a predetermined position relative to some path datum.

According to a further preferred version of the first aspect of the present invention the containment comprises a housing defining a passage in which the light

conducting element is located, the passage having an inner end located within the containment serving as a wall of a chamber within the containment; the chamber serving to locate the element for emitting light. Typically the housing is opaque.

According to as first preferred version of the further preferred version of the first aspect of the present invention the chamber serves to house, or has a boundary region serving to define, means for reflecting or refracting light emitted by the element for emitting light.

According to a second preferred version of the further preferred version of the first aspect of the present invention the containment incorporates integral fins or is in good thermal exchange contact with a member incorporating fins; the fins serving to radiate heat generated by the element for emitting light and conducted to the fins by way of the containment.

According to a third preferred version of the further preferred version of the first aspect of the present invention or any preceding preferred version of the further preferred version the containment includes a yet further passage whereby the chamber can be communicated with from outside the device to provide for varying the pressure in the chamber and/or for supplying the chamber with a gas or vapour.

According to a fourth preferred version of the further preferred version of the first aspect of the present invention or any preceding preferred version of the further preferred version the containment comprises two parts demountably coupled to one another so that on being uncoupled they serve to expose the interior of the chamber. Typically the two parts of the containment each provide or contain a path of electrically conducting material and when assembled the two paths are:

electrically insulated from one another; and

coupled to the element for emitting light

to enable electrical power to be supplied to the element.

According to a fifth preferred version of the further preferred version of the first aspect of the present invention or any preceding preferred version of the further preferred version the containment includes a further passage for a conducting means

for supplying electrical power to the element for emitting light. Typically the further passage can extend axially along, or radially from, the device.

According to the first aspect of the present invention or any preceding preferred version thereof the element for emitting light comprises one or more of the following: a resistive filament; an arc; a discharge device; a solid state emitter (pn junction), a coherent light source with means for light stimulation and amplification.

According to a second aspect of the present invention there is provided a method of fabricating a light outputting device according to the first aspect or any preferred version thereof is characterised by the steps of:

providing the light conducting element in the form of a longitudinal member with end faces and an outer surface apart from the end faces;

locating around the light conducting element a sleeve member of greater length than the light conducting element with a first end of the light conducting element at or near one end of the sleeve so as to leave a length of sleeve projecting beyond the opposite end of the light conducting element to the first end;

the opposite end of the light conducting element to the first end forming, at least in part, the light input region;

causing the sleeve member to be contiguously juxtaposed with the outer surface of the light conducting element;

locating the element for emitting light in the length of sleeve projecting beyond the opposite end;

deforming the length of sleeve so as to form together with the light input region of the light conducting element the containment for the element for emitting light; and

sealing the deformed length of tube to cause the containment to form a gas tight enclosure for the element for emitting light.

According to a first preferred version of the second aspect of the present invention the sleeve is of a similar material to the light conducting member and the step of causing the sleeve member to be contiguously juxtaposed with the outer surface of the light conducting element comprises a fusing operation. Typically the sleeve is of a translucent or opaque material having a thermal coefficient of expansion

comparable with that of the light conducting member.
According to a second preferred version of the second aspect of the present invention or the first preferred version thereof the step of locating the element for emitting light in the length of sleeve projecting beyond the opposite end includes locating conductors for supplying energy to the element.

According to a third preferred version of the second aspect of the present invention of any preceding version thereof the step of locating the element for emitting light in the length of sleeve projecting beyond the opposite end includes locating a mirror element for reflecting light generated by the element for emitting light to enable the mirror element to be enclosed with the element for emitting light in the containment prior to the deforming and sealing steps.

According to a fourth preferred version of the second aspect of the present invention or of any preceding preferred version thereof the step of locating the element for emitting light in the length of sleeve projecting beyond the opposite end includes locating a lens element for refracting light generated by the element for emitting light to enable the lens element to be enclosed with the element for emitting light in the containment prior to the deforming and sealing steps.

According to a third aspect of the present invention there is provided an array comprising at least two devices according to the first aspect of the present invention or fabricated by means of a method according to the second aspect and a light guide array linking the or at least one light conducting element to a light output location remote from at least one device. Typically at least one of the devices is coupled to a heat exchange means whereby heat generated by the or each device is dissipated such as by natural or forced convection utilising gas or liquid coolant.

According to a first preferred version of the third aspect of the present invention there is incorporated in the light guide array or the light output location means for varying the colour of light originating from at least one of the devices.

According to a second preferred version of the third aspect of the present invention at least one of the devices is demountably attached to the array and a magazine of

replacement devices is located for the demountably attached device to enable the demountably attached device to be readily removed and replaced by a replacement device from the magazine thereof.

An object of this invention is to collect light close to the source such as a filament, arc, diode, NP junction, laser or semi-conducting light emitting device where the light energy is at its most concentrated. This saves on a requirement for larger and or complex external lenses and mirrors. The light is positioned close to, and is fed directly into, a light guide, so saving energy losses which arise from the use of: reflectors, lenses, and containment housings. As the device can use any simple or complex state of the art system it can be mass produced.

Even where direct connection is not required the light energy is output in a very concentrated form which allows smaller light guides to be connected to the devices output. This contrasts with larger light guides required with presently existing systems utilising less efficient light generation and conducting systems.

Where very large amounts of energy are required, existing devices are limited by overheating of the separate components. The present invention enables a cooling system to be readily employed. If required excess heat energy can be made use of.

The present invention also provides for devices of greater strength than heretofore to improve longevity. Typically these can be used in vehicles where, for example, the device can be linked to a vehicle cooling system. The invention also provides for devices to be much more efficient so in many cases avoiding the need for a cooling systems which is required in current applications.

The combined emission and collection device, surrounds an element for light emission such as a filament or arc, or a laser or light emitting semi conductor device, by one or more light conducting elements, that are slightly spaced from the element, arc, etc. or in the case of solid state lights, i.e. light emitting diodes, the light conducting element is inserted into a solid body. In all cases the light conducting element, is designed to carry light from the source of the bulb, or device, to the edge of its case, through vacuum or gas, liquid or solid. The light conducting element can

stop at or on the inside of the case, or continue through the outer case. which is still sealed or solid, to a distance that is directly to the required output of the light, or to a distance and shape, that is suitable for the easy connection of flexible or other light guides, or light conducting devices.

The number of these internal light conducting elements can be reduced by internal mirrors and or lenses, and their collection or function, enhanced by the use of state of the art materials, solids or coatings. The covering of the bulb, solid or coatings may no longer all be required, for the transferral of light, and therefore can now be constructed by moulding, from a non transparent state of the art material, for example a metal, that would allow the total device to be stronger quite apart from enabling the provision of any other desired property. A gas or liquid, or case can be used to circulate a gas, or liquid, to collect heat energy for cooling or energy maximisation, thorough for example a heat exchanger, which can be incorporated as part of the device.

A fluorescent material can be used in conjunction with, or incorporated in, a device according to the present invention so that on being excited by light emission from the light emitting element the material fluoresces to generate a distinctive optical effect.

The devices of the invention lend themselves to a wide range of applications some of which will be exemplified or referred to later. Usage of the invention in a communication context is particularly appropriate in view of the efficient usage of light and the possibility of miniaturisation made available by the present invention.

Brief Description of Drawings

Exemplary embodiments of the invention will now be described with reference to the accompanying drawings of light emitting and channelling devices in which:

Figure 1 shows a side view of a first embodiment;

Figure 2 shows a top view of a second embodiment;

Figure 3 shows a side view of a third embodiment;

Figure 4 shows from a top view a section through a fourth embodiment;

Figure 5 shows a side sectional view of the device of Figure 4;

Figure 6 shows a side view of a fifth embodiment;
Figure 7 shows a side view of a sixth embodiment; and
Figure 8 shows the manufacture of a seventh embodiment.
Figures 9A to C show longitudinal and end views of an eighth embodiment; and
Figure 10 is a longitudinally vertical section of a ninth embodiment.

MODES FOR CARRYING OUT INVENTION

FIGURE 1

Device 10 comprises of a light emitting element 11 housed in a containment 14 in this case of glass which serves to retain a vacuum in plenum 12 around light emitting element 11. Conducting elements 13 extend towards element 11 and serve to capture most of the energy emitted by the element 11. This energy is guided out of the device to the end of the light conducting element 13 outside the containment 14 where the light energy can be used directly, or by way of a light emission system utilising fibre optic cable for onward transmission. Each light conducting element 13 is solid and is sealed to the containment 14 at region 16 with axis A directed towards element 11. Each light conducting element has an axial length at least three times the lateral width of the conducting element meansured transvers the axis A. The sealing ensures a required vacuum is maintained in the containment 14. Each conducting element 13 has an end face E set square, and close to, emitting element 11 to provide for efficient light transfer from emitting element 11 into each conducting element 13.

The containment 14 is mounted on a base 17 by means of which the device 10 is connected to a power supply. In this case the bases 17 comprises two main parts 17A, 17B that are electrically insulated from each other by insulator 18 to provide a means of connecting the element 11 to a supply of electricity. The base 17 is formed with a screw thread 19 enabling the device 10 to be secured to a conventional socket.

FIGURE 2

Device 20 is similar in many respects to that described above in relation to Figure 1. However in this embodiment light emitting element 21 is located in a plenum 22 having a gas filling rather than a vacuum. Containment 24 is made from quartz glass

and serves to locate conducting elements 23 with axis A directed towards and their end faces E close to and square with the emitting element 21 to provide for effective light transfer axially into each conducting element 23. Base 27 provides for the accurate location of the of the device.

FIGURE 3

Device 30 is constructed as described above in relation to Figure 1 saving that in this embodiment only one light conducting element 33 is located with its axis A and end face E directed towrads one side of light emitting element 31. Light from the other side of the emitting element 31 is reflected back into end face E of the conducting element 33 by a shaped and coated reflector 38. Base 37 functions in an identical manner to that of base 17 referred to in the description of Figure 1.

FIGURES 4 AND 5

Device 40 has a light emitting element 41 surrounded by four conducting elements 43A to D. The conducting elements 43A to D pass through the wall of containment 44 by ways of seals, typically seal S for element 43B. Each conducting element 43A to 43 D has longitudinal axis directed towrads element 41. End faces E of each conducting element within the containment are set squarely towards the emitting element 41. As a high power device 40 containment housing 44 is made from a state of the art ceramic material which is heat conducting and extremely strong. The containment has cooling fins 49. Plenum 42 serves to retain a gas filling. The light emitting element 41 is coupled by conductors C1, C2 of substantial cross section.

FIGURE 6

Device 60 has a light emitting element 61 is provided with a back reflector 68 which emits a narrow beam of light energy which is in turn collected by end face E of light conducting element 63 and so transmitted through containment 64 to output 65. Conducting terminals 67A, 67B provide electrical power to the light emitting element 61 and the containment 64, in this case of plastics material, supports the terminals 67A, 67B in relation to each other.

FIGURE 7

This embodiment is a device 70 similar to that described in relation to Figure 6

saving that light emitting element 71 is inserted directly into a light conducting element 73 to contact end face E of the conducting element 73. In this case containment 74 forms a part of light conducting element 73 which is of plastics material. The light emitting element 71 can be any state of the art electromagnetic energy emitting material and can be customised to match the light conducting element 73 or elements. The design of the whole device 70 is adapted to minimise any interference with the output of the electro magnetic energy while enhancing its functional efficiency.

The light conducting element 73 is of quartz glass where necessary coated or multi coated or enhanced by a light modifying coating. The light conducting element 73 can itself be made by one or more smaller coated elements fused together. These elements 73 can be manufactured from any state of the art material or process with coatings as above or process that can enhance transmission function of desired electro magnetic energy wave lengths.

The shape of these light conducting element 73 is matched in number, size and shape to maximise the collection of electromagnetic energy from the light emitting element 71. Preferably these light conducting elements 73 are solid, composite or hollow or liquid or any combination of these or other state of the art light guiding systems. The elements can be curved, flexible, sheathed, straight, coiled, amorphous, or have any property or shape that enhances its function. lenses or other state of the art light modifiers. Reflectors corresponding to those shown in Figures 3, 6 or 7 may be of any material or shape and can be used in or on any internal or external part of the device and be coated or treated with any state of the art coating or enhancement method.

FIGURE 8A TO 8E
This shows in sequence the fabrication of a light emitting device.

Figure 8A shows a sleeve 81 of quartz glass with flame polished ends 82, 83. The sleeve is of length L1 and internal bore B

Figure 8B shows a light conducting element in the form of a quartz glass rod 84 of

length L2 and external diameter D with square cut ends 85, 86.

Figure 8C shows the sleeve 81 positioned around rod 84 with end 82 of sleeve 81 aligned with ends 85 of rod 84. As the length L1 of the sleeve is considerably greater than rod 84 the sleeve extends over a further distance X beyond end 86 of the rod 84 to provide a recess 87. End 86 of rod serves as a light input region for light entering the rod 84 as will be described hereafter.

The sleeve 81 and rod 84 are then fused together to form a unified structure. As the material of the sleeve 81 and the rod 84 are identical thermal cycling does not result in the generation of thermal stressing. If necessary the fused or otherwise linked sleeve and rod can be subjected to an annealing treatment to remove internal thermal stresses generated by the production process.

Figure 8D shows the unified structure prior to closure of the recess 87 by heating and closing. Light emitting element 88 and conductors 89, 90 are shown located in the recess 87 with the light emitting element set 1mm, or closer, to end 86 of the rod 84 which serves as a light input region for the rod 84. The outer length X2 of projecting length X of sleeve 81 is then heated and pressed to form a sealed closure through which conductors 89, 90 extend from the containment C for element 88. By juxtaposing light emitting element 88 very close to end 86 (the light input region) of rod 84 which serves as the light conducting element of the device the element 88 when energised causes the device to function as a very efficient light utilising and supply means. Axis A of rod 84 is directed towards element 88.

Figure 8E shows the completed device D with projecting conductors 89, 90 available for attachment to a power supply. The light emitting element 88 is shown within a plenum 91 which in this case has been evacuated to maintain a vacuum in the vicinity of the element 88.

For use the device D can be used as a discrete item to provide a compact and bright source of light or be coupled to a further light conductor or other light using device by way of end face 85. If required the device can be used in conjunction with a light conductor which can split to create at least two further light paths or to provide a

lateral light projection from the side wall of the light conductor.

The device D has been described in terms of a circular section sleeve 81 and a rod 84. However elements of other cross sections can be used depending on the required path to be provided for the light . In addition the cross section of the light conducting path can be changed for whatever reason. This the device D can be used as a circular section light source for a light conducting path which changes in cross section to provide an outlet, display, end of non-circular shape.

Once the device has been formed the outside of the device, or at least of the containment, can be coated, such as with silver or other reflective medium, to optimise the output of the light emitting element into the light input region of the light conducting element. If necessary the step of forming the containment can provide for the containment itself, at least in the vicinity of the emitting element, to have a shape which contributes to the effectiveness of light output from the device. Thus with a coating the specially shaped region of the containment can provide an external mirror with the light emitting element at a focal point of the mirror. Alternatively the specially shaped region can form a lens providing for refraction of light emitted from the emitting element.

In other embodiments of the device the step of locating the light emitting element within the sleeve length X can also include the location of mirror and/or lens elements relative to the light emitting element prior to the forming of the sealed containment.

FIGURE 9A TO C

A light emitting device 11 has a containment made up of first and second coaxial thick walled tube members (first member 12 and second member 13) with a common longitudinal axis 14. The first member 12 and second member 13 are of tungsten. Molybdenum is also suitable. First member 12 has a spigot 15 which serves to align with annular recess 16 of second member 13.

The first member 12 has a passage 17 extending through it in which is located a light

conducting element 18 of quartz coaxial with axis 14. The light conducting element has an axial length at least 2.5 times its mean width transvers the axis 14. The first member 12 is formed as a very close fit around the light conducting element 18 so that the first member 12 is in good heat transfer relationship with the element 18. Apart from the protection provided to the light conducting element by the first member 12 the heat transfer relationship serves to avoid the maintenance of any hot spots in the light conducting element by providing for efficient heat removal. The first member 12 is provided with an array of fins along its outer side, typically fin 19, to provide for an enhanced area for radiating heat transferred to the first member 12. Outer end 20 of the element 18 is located at the same level as outer surface 21 of first member 12. The outer surface 21 is provided with threaded holes 22 whereby a fibre optic harness and/or filter can be accurately aligned with and secured to device 11.

The second member 13 has a second passage 23 extending through it in which is mounted units 25, 26 each made up of a quartz half rounded block each incorporating a conductor 25A, 26A. These conductors provide a pair of axial conductors for powering a light emitter as will be described hereafter. This configuration enables a good gas tight closure to be maintained while providing electrical power supply to a lamp forming a part of the device 11 as will be described hereafter .

The assembled members 12, 13, their associated quartz member 18 and the pair of members 25, 26 when assembled serve to define a chamber 28 in which is located a light emitting element 29 in the form of a discharge lamp 30 having a pair of electrical terminals 31, 32 coupled to, respectively, conductors 25, 26 whereby the lamp 30 is energised. A polished mirror 33 is located in the chamber 28 at a suitable position relative to the light emitting element 20 to provide for light from the lamp 30 to be reflected back towards input face 34 of conducting element 18.

A further passage 37 extends radially through first member 12 and serves to provide means for pressurising and/or adding gas to the chamber 28 to enhance optical performance of the device 11.

In this embodiment end wall 34 of chamber 28 formed by the end of quartz member

18 and end wall 40 of members 25, 26 are shown as plane surfaces. In an alternative embodiment one or other or both of end walls corresponding to end walls 16, 40 can be shaped to enhance the optical functioning of the device. Typically the end wall corresponding to wall 16 can be shaped to complement the shape of the adjacent face of the lamp 28 so as to enable the lamp to be set very close to the light input end of quartz member 18 so ensure that the light emitting element 29 is as close as possible to the light input end 16 of quartz member 18 for optimum transmission efficiency. Likewise a wall corresponding to end wall 40 provided by the conductors can be shaped and coated to provide an integral mirror to replace or supplement the mirror 33.

This exemplary embodiment shows a light emitting device making use of a casing in two or more parts (which can be insulated from one another) to enable an internally mounted light emitting means to be energised by way of the casing. The casing can contain gas or a solid based light emitting elements. The casings can be sealed in the case of a disposable device or be demountable so as to be capable of being serviced.

The light emitting elements can be a filament (such as a tungsten) run at an incandescent temperature or a gas discharge capsule in the from of a quartz container with electrodes with a solid salt which when activated melts to produce an arc in a gas.

FIGURE 10

Light emitting device 41 is made up of a quartz light conducting member 42 with a flanged end 42A and a quartz body member 43. The members 42, 43 are fused together along plane P to create a chamber 44 in which there is located a light emitting element in the form of a discharge lamp 45. From the rear of the body member 43 there extends a quartz axial member 46 having a concave inner face 47 having a mirror coating whereby to reflect light from the lamp 45 back towards face 48 of the chamber which provides a light input face to conducting member 42.

The axial member 46 serves to gas tightly house a conductor 49 for negative terminal 50 of lamp 45. The axial member 46 when the device is being fabricated also serves

to provide a gassing duct for the chamber 48. Positive terminal 52 of the lamp 45 is supplied by a conductor 53 extending radially into chamber 44

The device 41 can be used either as shown as a substantially quartz bodied component or be shrouded with a close fitting container corresponding to members 12, 13 described in connection with Figure 1A. Which version is used depends upon the application. Use of a close fitting container as discussed earlier contributes to a device of great mechanical strength and also enables heat to be removed from the vicinity of the device.

The design of a device as considered in the exemplary embodiments can either allow for the device to be opened up to enable the light emitting device to be replaced in part or provide for a disposable device which is replaced as a unit when it ceases to function.

The device of Figure 2 is either used directly as a lamp unit or can be coupled to a fibre optic harness by means of the conducting member 42 or an extension thereof.

The embodiments refer to the use of quartz. However other specialised glass or glass like materials can be used depending on the application involved.

A casing when of metal or some other electrical conducting material can be coated or juxtaposed with insulating material to insulate or protect or seal the material relative to adjacent components.

The light conducting elements (18, Figure 9; 42, Figure 10) have not been described in detail. However they can be solid or made from fibres coated with material having a lower refractive index which are fused together to provide a rod and a seal to the containment housing through which the rod passes. The fibres may be drawn before or as a collection after fusing into rods which can be parallel or coned

If desired the rods can be further shaped into lenses or coated with material of varying refractive index either sequentially or radially. Coatings can be included on any part or parts of a collection of fibres or rods. The ends of the rods can be etched,

cut or otherwise shaped and can incorporate micro lenses.

It is possible to provide a light conducting system of rods to provide a focusable light at their output which can be focused by remote control. Such control can also be used to control movement of lenses or mirrors mounted inside or outside the combined device and light conducting rods.

A wide range of applications can be achieved by use of the proposed light outputting device. In addition without energising the light emitting element the device can serve as a static reflector such as for 'cats eye' type applications serving to define carriageways, lanes or road boundaries for land vehicles and at air ports to guide aircraft when ground manoeuvring.

INDUSTRIAL APPLICABILITY

The various embodiments can be used on their own as light bulbs. In this form the outer end of the, or each, light conducting member can be left square with the axis of the member so that light is emitted in an axial direction. Such a device (or a plurality of them) can be used for downlighting. In an alternative version the end of the light conducting member can be cut at an angle to give a wedge shaped end so as to provide for illumination lateral to the main of the light conducting member. I a yet further version the outer end of the light conducting member can be faceted or otherwise shaped to provide a light output for decorative purposes. By having a light conducting member whose axial length is greater than its transverse lateral dimension (say a length at least three times its lateral dimension) the light emitted from the outer end of the conducting member is cool. Such light is beneficially used for locations where excessive heat generation can lead to damage or undesirable effects on the illuminated objects such as works of art, food stuffs, animals or humans.

In other embodiments the device of the present invention can be used in combinations where the, or each, device is optically coupled by way of its light conducting member or members to one or more optical systems. By way of example a small lighting unit is envisaged made up of three devices according to the present

invention each utilising a primary light with two light conducting members extending therefrom. Each device serves to generate a primary colour (one red, one blue, one yellow) one of the two light conducting in each case is fused into a single central member so that with the three devices powered up the three primary colours are mixed in the central member to provide a white output. The remaining single light conducting member from each device is kept separate so that at the optical outlet from the unit there are four light outputs: the central white and single red, blue and yellow output. Such as device can be made in a small envelope and provide a range of illuminating functions.

It is also considered that an embodiment of the present invention could be made up of a unit including one or more devices utilising a sold state light emitter (pn junction) could be used to not only to transmit light but also to respond to light falling on them from the or at least one light conducting element of the device. This takes advantage of the fact that such a solid state device on being energised by a current acts to emit light but also conversely if the solid state device is illuminated it generates a current. Thus with a device running in a steady state with the light conducting member radiating from its outer end a given light output in the event a change occurs causing the light output to be varied this generates a feed back effect detected by the pn junction emitter which would in turn be detected by appropriate circuitry connected to the pn junction.

Any of the light emitting elements mentioned in connection with the embodiments can be used to provide for any wave length or be adopted to provide a combination of wave lengths of electro magnetic energy. Typically a light emitting element having different regions may be fitted within a given containment. Each region can be energised separately and each region serves to generate a different wavelength light compared to the remaining regions.

The combined device mentioned above may have at any part or parts of its construction coatings that are so spaced that when a coherent light source of monochromatic light is emitted from the light emitting device. The combined effect being to amplify that emitted light that is then further enhanced by materials chosen for their release of electromagnetic energy, when stimulated by the energy from the

light emitting element or elements of the device.

The device may be so shaped that the element is almost touching or slightly spaced from its containment so allowing the light to be collected close to the element but on the outside of the housing by a light conducting element attached to the housing containment and utilising one or more reflectors, to enhance the systems function.

The embodiments shown in Figure 6 and 7 are particularly suited for remote light indication systems. The light conducting elements 63, 73 can be taken directly to a lighting requirement via one or more conduit guiding systems. The devices 60, 70 would be disposable and held in place by a simple retainer The device can be removed from the remainder of the system for servicing or replacement without extensive or indeed any removal of local components such as bulkheads or cosmetic casings or coverings.

Desirable light modification can be achieved at any point in a given device for example, by moving as shown in Figure 4 and 5 one or more of the light conducting elements 43 towards or away from the light emitting element 41 inside the containment housing 44. In this way the output light energy can be made more or less concentrated.

Suitable existing devices and means can be used to provide for light generated by light emitting devices according to the present invention to be changed in scale of illumination, illumination level and in colour.

Devices as mentioned above can require very little energy and can be used to provide miniature lighting; for all applications where powerful hands free light is required especially in hobbies such as attachment to diving equipment or fishing equipment as reel or rod illumination or other hobbies or pastimes, industrial or domestic situations. They can be made as disposable and/or sterile and/or reusable especially in medical and surgical applications.

Miniature versions of the proposed devices can act as lighting or indication systems for miniature electronic assembles or components or act as relays or communication

links or activate remote control of equipment or other sub assemblies. Lengths of light guides can be supplied as part of the component, such that service or construction personnel can cut the fibre easily to the required length and insert the output end directly into a holding device or into a conduit as described above.

One or more of these miniature devices emitting infra red or other wave lengths, into an adjacent similar light conducting element can be used to communicate a function or desired effect or message. The receiving fibre being connected in a similar way to a receiving and activation device.

The element for emitting light can include a number of filaments or other light emitters so that the light emitting device can emit at least two different light outputs depending on which filament or light emitting device is energised.

In addition an element for emitting light can be coated to enhance the direction of emission of light by the element.

The exemplary embodiments refer to the use of glass coatings for the light conducting element. However if necessary other coating materials can be used typically metal ones or opaque or translucent ones to vary the light transmission characteristics. In addition coating materials can either be formed of or be in good thermal conducting contact with metal or other heat transferring means providing for heat generated by the light emitting element to be conducted away from the device.

Coating of the light conductor will also serve to provide an optimised form of light transmission along the light conductor.

In many applications heat will be readily dissipated from the device whether by natural or forced convection. In applications where the device is located in a confined space or for some other reason is liable to overheating then a thermal cut out can be incorporated in the device or in good heat transfer contact with it so that in the event of overheating the power supply to the light emitting element is cut off and the device allowed to cool until the thermal cut off device is enabled to restore the power supply.

In small scale applications systems according to the invention can be incorporated into clothing or articles or where ever general or artistic lighting requirements have a requirement for the characteristics mentioned in this application.

For large lighting situations central lighting can be achieved by large versions of the above device. These large devices can utilise high power light emitting elements such as arcs. These devices can be used to light a whole building or other defined area. The large amount of heat generated by these units can be controlled in a safe maintenance area and incorporated into the heating system of the building, via heat exchangers and other state of the art exchange and control systems. The light is conducted from the light emitting unit, in this case an arc, via light conducting elements as described above. The containment for the arc and/or the light conducting element incorporate fins or other means to provide for efficient heat transfer from the containment and/or the light conducting element to a coolant circuit utilising gas or liquid coolant displaced by way of a natural or forced convention coolant circuit. Such units can be used to provide cold light for illumination but also to provide a substantial heat supply such as can be utilised to maintain or top up a heat supply for, say, an air conditioning unit. A typical use for such an installation would be in a store or supermarket where the arc system provides for general and sign illumination and the heat generated by the arc system can be used to provide for background air or water heating and/or air conditioning. Such a system can also be incorporated into day light collection systems as enhancement or back up with the energy being converted to heating water when the sunlight provides enough electricity for total lighting requirements but can reverse instantaneously should the sun be obscured such as by cloud.

The above devices can be used in any situation where remote and/or efficient light or heat energy is required for communication or inspection or control or heating or educational or any other application. For example a small device directly connected to a flexible or other light guide can be kept on an enclosed or open reel which is then pulled out and used as an inspection light the device being on a reel which is sprung loaded so that when a retainer is released the light guide springs back into its case.

Either end of the light conducting device can be shaped as a lens or coated or modified to enhance function by any state of the art -process or light modification technique for example polarisation of the transmitted light.

All or part of a light conducting element can be an amorphous light conducting material such that when pressure is applied to the external part of the light conducting element the shape of its end or other part is altered rather like a remote controlled amorphous lens.

A particular application for the present invention would be for endoscope for internal inspection of human or animal bodies where the miniaturising possibilities of the present invention serve to provide for advantageous designs.

The present invention provides for light outputting device and systems which can be utilised in a wide range of applications including: commercial and residential locations; medical and surgical sites; illumination of simple or elaborate displays, representations at point of sale devices; and control system displays varying from the simple to the very elaborate; signalling systems.

The invention also envisages an array made up of at least two light emitting devices each being linked by a light guide array linking the or, at least one light conducting element of a device, to a light output location remote from at least one device. Typically the array can, where necessary, be cooled by natural convection. Alternatively heat exchange elements incorporated in the device or the light guide array or both can be subject to natural or forced convection flows of air, liquid or a mixture. As an example a large scale installation using powerful light and heat emitting elements can provide for efficient illumination and heating (with or without at least a partial contribution to air conditioning) of a shopping, catering, medical, commercial or manufacturing location.

By incorporating suitable devices the invention can provide not only for fixed levels on illumination with any practical degree of definition but also for changes in light levels and colour. By incorporating mirrors and lenses within the enclosure it is possible for such devices to be small, accurately aligned and virtually incapable of

being damaged by anything except virtual destruction of the device.

A device according to the present invention can be used for a range of applications where both light and heat are required to take advantage of inherent strength of a unit (for example of the type described in connection with Figure 8). By providing a small bore in the light conducting member the device can be used as a pre-heater for a fuel supply.

Because of its inherent strength at least in small scale versions and its ability to operate at low voltages a device according to the present invention can be used in situations where safety is of paramount importance. In a decorative context low powered devices can be used in locations subject to crowding such as pubs, restaurants or transport such that in the event of damage, whether malicious or accidental will merely result in the loss of decorative illumination without exposure of conductors bearing life endangering voltages or currents.

The present invention lends itself through one or more of its embodiments to a very wide range of applications.

Electronic instrumentation where the light emitting elements for the device include single or multiple light emitting diodes, near infra-red emitter, single or multiple white lights.

Other possible applications include

Power usage consumption/Brightness	*Applications*
Low/ Bright devices	Mass production of cheap devices for hobbies, inspection, medical, dental.
Higher/ High brightness	Miners head lamps, surgical, bicycle lighting, industrial inspection
Low/ Bright	Particularly in miniaturised versions: Diving, surgical, mining, video and digital cameras, automotive.
High-Low voltage/ Special high brightness, high colour temperature	Aircraft, automotive, marine, industrial.
High/low voltage/ Very high brightness	Domestic light bulb replacement. Mini light bulb replacement.
High/Multi element,	

gas or liquid cooled, 'cold' light,	Vandal proof lighting, energy efficient, safe light lighting system for hazardous environment, water heating or topping up in public utility uses, fire detection, security systems, hospitals, offices, retail, industrial, catering, hotels, large domestic. Air conditioning.

CLAIMS

1 A light outputting device comprising:

a containment for housing an element for emitting light;

at least one axially extending light conducting element having an axial length substantially greater than its width transverse the axis; the light conducting element being aligned axially with the element for emitting light by means of the containment or an extension thereof; the, or each, light conducting element having a light input region such as an end face whereby light generated by the element for emitting light is caused to pass axially into the or each light conducting element by way of its associated light input region.

2 A light outputting device as claimed in Claim 1 wherein the containment or an extension thereof serves to locate the element for emitting light closer to the light input region of the, or each, light conducting element than to the major part of the containment remote from the light input region or regions.

3 A light outputting device as claimed in any preceding claim incorporating a reflector located relative to:

the element for emitting light and

the, or at least one, light conducting element

so as to reflect light from the element for emitting light axially into the, or at least one, light conducting element by way of its associated light input region.

4 A light outputting device as claimed in any preceding claim incorporating a refractor located relative to:

the element for emitting light and

the, or at least one, light conducting element

so as to refract light from the element for emitting light axially into the, or at least one, light conducting element by way of its associated light input region.

5 A light outputting device as claimed in any preceding claim wherein the containment is substantially opaque and light can only pass out of the containment from the element for emitting light by way of the, or at least one,

light conducting element.

6 A light outputting device as claimed in any preceding claim incorporating heat transfer means such as a heat sink in intimate contact with, or forming an integral part of, the containment whereby heat generated by the element for emitting light can be dissipated.

7 A light outputting device as claimed in any preceding claim incorporating heat transfer means such as a heat sink in intimate contact with, or forming an integral part of the, or at least one, light conducting element whereby heat generated by the element for emitting light can be dissipated.

8 A light outputting device as claimed in any preceding claim wherein the containment serves to define a plenum about the element for emitting light whereby a vacuum or an inert gas or a mixture of gases to be maintained by means of the plenum about the element for emitting light.

9 A light outputting device as claimed in any of preceding claims 1 to 7 wherein the element for emitting light is contained in an envelope within the containment and the envelope serves to define a plenum about the element for emitting light whereby a vacuum or an inert gas or a mixture of gases to be maintained by means of the envelope about the element for emitting light.

10 A light outputting device as claimed in any preceding claim incorporating means for varying the colour of light output by the device.

11 A light outputting device as claimed in any preceding claim wherein the element for emitting light comprises more than one light emitter so that the element for emitting light can be used to emit more than one light wavelength.

12 A light outputting device as claimed in any preceding claim wherein the containment serves to provide a location means for the device adapted for complementary engagement with an external device whereby the device can be demountably attached by means of the light conducting element or an

extension thereof to a further light conducting path in a predetermined position relative to some path datum.

13 A light outputting device as claimed in Claim 1 wherein the containment comprises a housing defining a passage in which the light conducting element is located, the passage having an inner end located within the containment serving as a wall of a chamber within the containment; the chamber serving to locate the element for emitting light.

14 A light outputting device as claimed in Claim 13 wherein the housing is opaque.

15 A light outputting device as claimed in Claim 13 or 14 wherein the chamber serves to house, or has a boundary region serving to define, means for reflecting or refracting light emitted by the element for emitting light axially into the, or at least one, light conducting element by way of its associated light input region.

16 A light outputting device as claimed in Claim 13, 14 or 15 wherein the containment incorporates integral fins or is in good thermal exchange contact with a member incorporating fins; the fins serving to radiate or otherwise dissapate heat generated by the element for emitting light and transferred to the fins by way of the containment.

17 A light outputting device as claimed in any of preceding Claims 13 to 16 wherein the containment includes a yet further passage whereby the chamber can be communicated with from outside the device to provide for varying the pressure in the chamber and/or for supplying the chamber with a gas or vapour.

18 A light outputting device as claimed in any of preceding claims 13 to 17 wherein the containment comprises two parts demountably coupled to one another so that on being uncoupled they serve to expose the interior of the chamber.

19 A light outputting device as claimed in Claim 18 wherein the two parts of the containment each provide or contain a path of electrically conducting material and when assembled the two paths are:

electrically insulated from one another and

coupled to the element for emitting light

to enable electrical power to be supplied to the element.

20 A light outputting device as claimed in any of preceding Claims 13 to 18 wherein the containment includes a further passage for a conducting means for supplying electrical power to the element for emitting light.

21 A light outputting device as claimed in Claim 20 wherein the further passage can extend axially along, or radially from, the device.

22 A light outputting device as hereinbefore described with reference to and as illustrated in Figure 1, or Figure 2, or Figure 3, or Figures 4 and 5, or Figure 6 or Figure 7 or Figure 9 or Figure 10 of the accompanying drawings.

23 A light outputting device as claimed in any preceding claim wherein the element for emitting light comprises one or more of the following: a resistive filament; an arc; a discharge device; a solid state emitter (PN junction), a coherent light source with means for light stimulation and amplification.

24 A light outputting device as claimed in any preceding claim wherein the, or each, light conducting element is of fused quartz or other glass like material.

25 A light outputting device as claimed in any rpeceding claim wherein the containment is of fused quartz or other glass like material.

26 A method of fabricating a light outputting device as claimed in preceding claims 1 to 25 characterised by the steps of:

providing the light conducting element in the form of a longitudinal member with end faces and an outer surface apart from the end faces;

locating around the light conducting element a sleeve member of

greater length than the light conducting element with a first end of the light conducting element at or near one end of the sleeve so as to leave a length of sleeve projecting beyond the opposite end of the light conducting element to the first end;

the opposite end of the light conducting element to the first end forming, at least in part, the light input region;

causing the sleeve member to be contiguously juxtaposed with the outer surface of the light conducting element;

locating the element for emitting light in the length of sleeve projecting beyond the opposite end;

deforming the length of sleeve so as to form together with the light input region of the light conducting element the containment for the element for emitting light; and

sealing the deformed length of tube to cause the containment to form a gas tight enclosure for the element for emitting light.

27 A method of fabricating a light outputting device as claimed in Claim 26 wherein the sleeve is of a similar material to the light conducting member and the step of causing the sleeve member to be contiguously juxtaposed with the outer surface of the light conducting element comprises a fusing operation.

28 A method of manufacturing a light outputting device as claimed in Claim 26 wherein the sleeve is of a translucent or opaque material having a thermal coefficient of expansion comparable with that of the light conducting member.

29 A method of manufacturing a light outputting device as claimed in Claim 26, 27 or 28 wherein the step of locating the element for emitting light in the length of sleeve projecting beyond the opposite end includes locating conductors for supplying energy to the element.

30 A ethod of manufacturing a light outputting device as claimed in Claim 26, 27, 28 or 29 wherein the step of locating the element for emitting light in the length of sleeve projecting beyond the opposite end includes locating a mirror element for reflecting light generated by the element for emitting light to

enable the mirror element to be enclosed with the element for emitting light in the containment prior to the deforming and sealing steps.

31 A method of manufacturing a light outputting device as claimed in any of preceding claims 26 to 30 wherein the step of locating the element for emitting light in the length of sleeve projecting beyond the opposite end includes locating a lens element for refracting light generated by the element for emitting light to enable the lens element to be enclosed with the element for emitting light in the containment prior to the deforming and sealing steps.

32 A method of manufacturing a light outputting device as hereinbefore described with reference to the accompanying drawings.

33 An array comprising at least two devices, as claimed in any of preceding claims 1 to 25 or fabricated by means of a method as claimed in Claims 27 to 32 and a light guide array linking the or at least one light conducting element to a light output location remote from at least one device.

34 An array as claimed in Claim 33 wherein at least one of the devices is coupled to a heat exchange means whereby heat generated by the or each device is dissipated such as by natural or forced convection utilising gas or liquid coolant.

35 An array as claimed in Claim 33 or 34 incorporating in the light guide array or the light output location means for varying the colour of light originating from at least one of the devices.

36 An array as claimed in Claim 35 wherein at least one of the devices is demountably attached to the array and a magazine of replacement devices is located for the demountably attached device to enable the demountably attached device to be readily removed and replaced by a replacement device from the magazine thereof.

37 An array comprising at least two devices according to Claims 1 to 25.

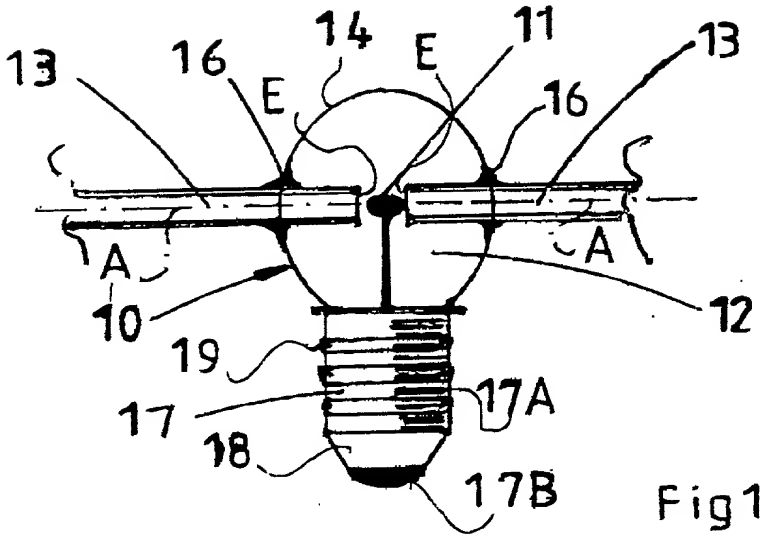


Fig1

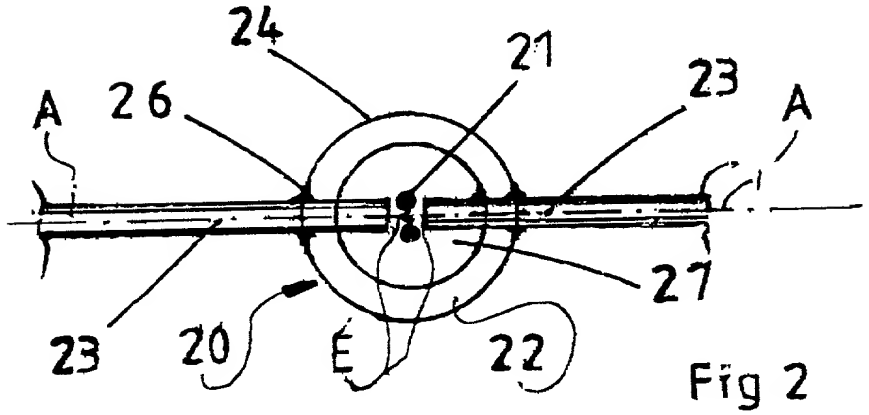


Fig 2

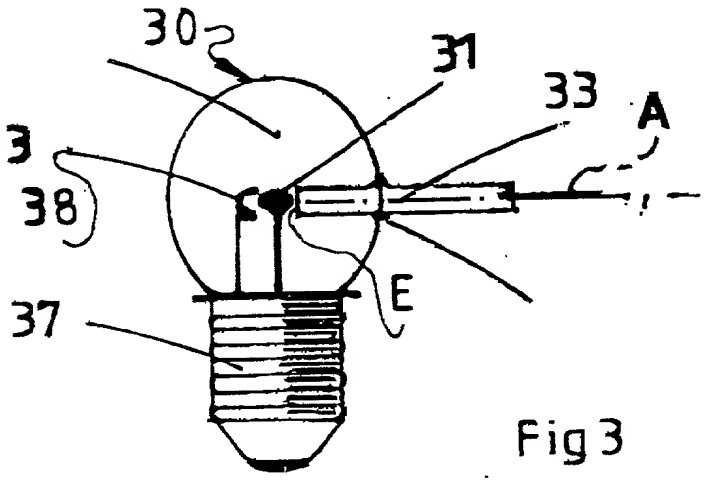


Fig 3

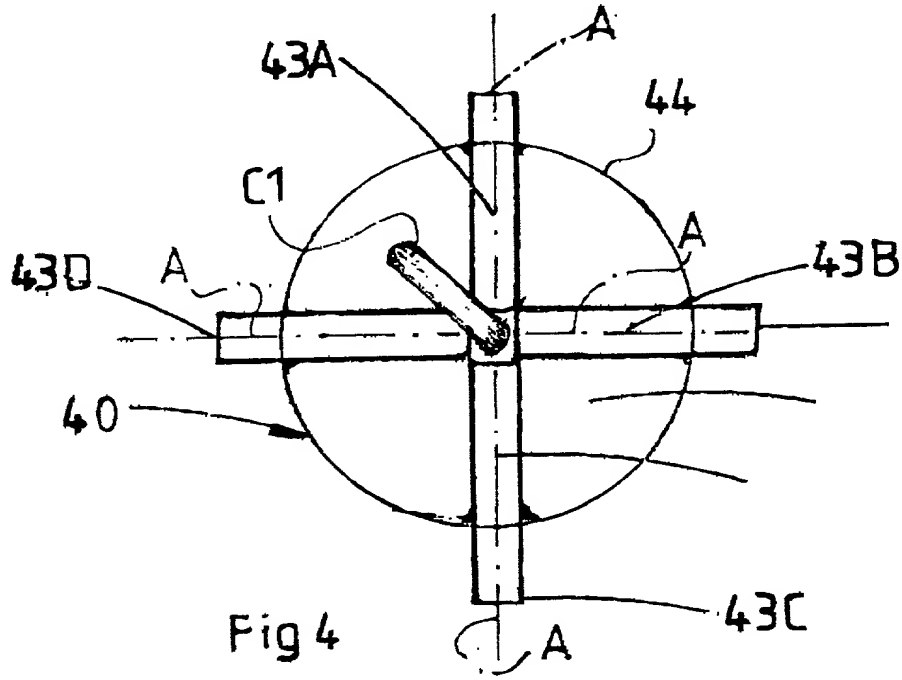
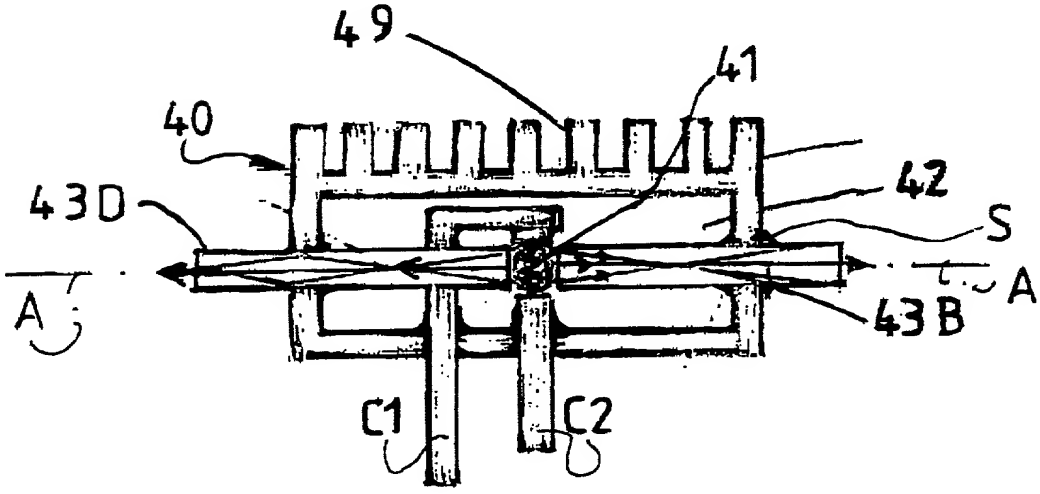


Fig 4



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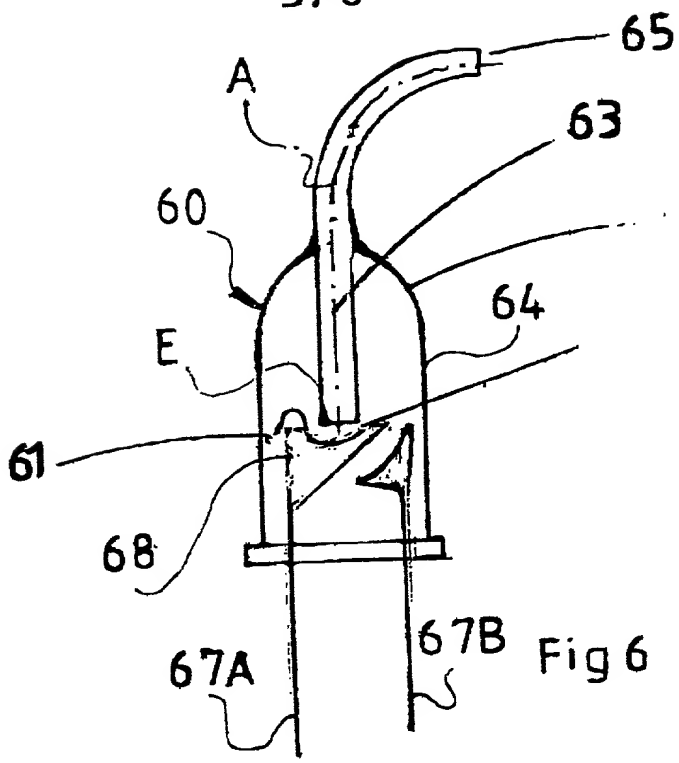

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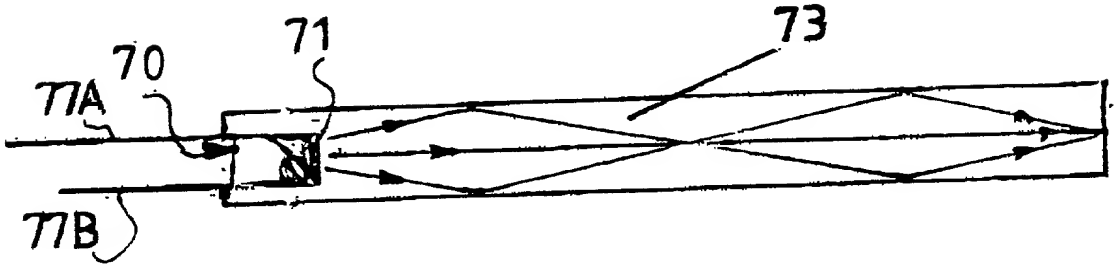


Fig 7

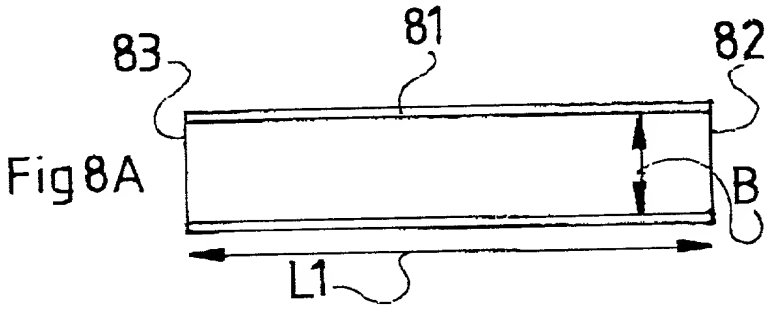


Fig 8A

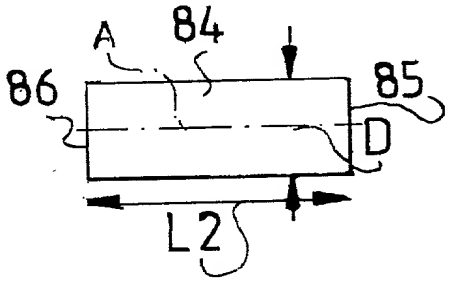


Fig 8B

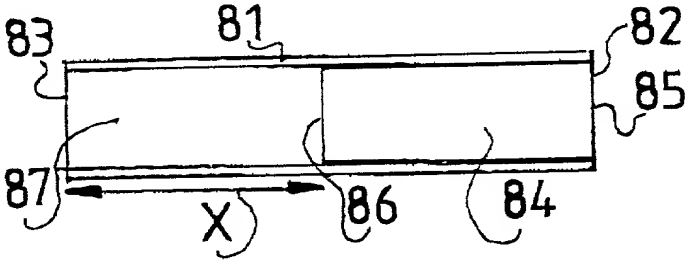
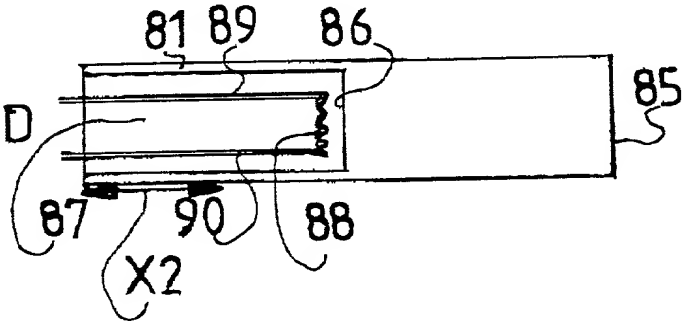


Fig 8C



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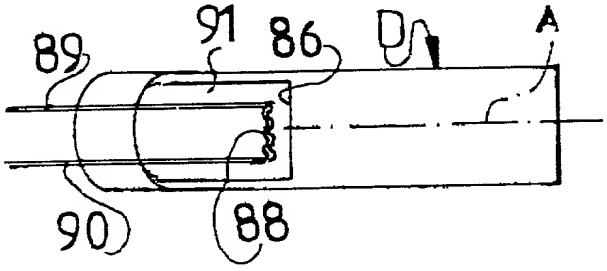

Fig8E

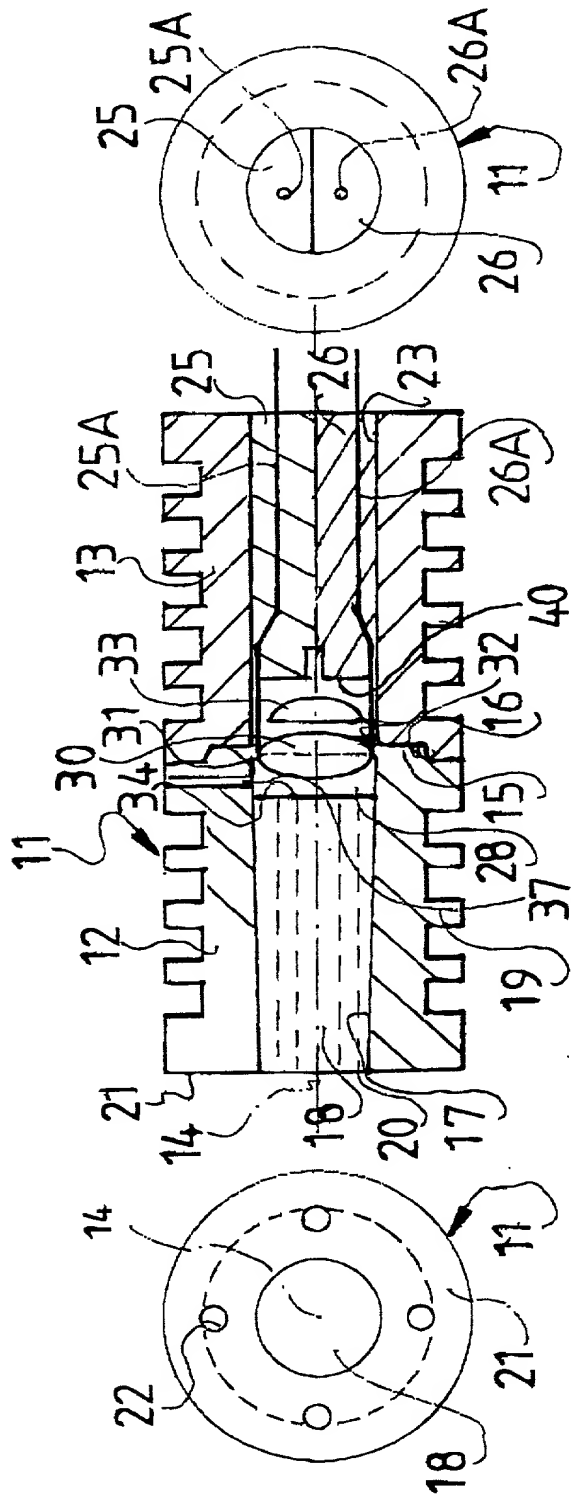

Fig9C

Fig9A

Fig9B

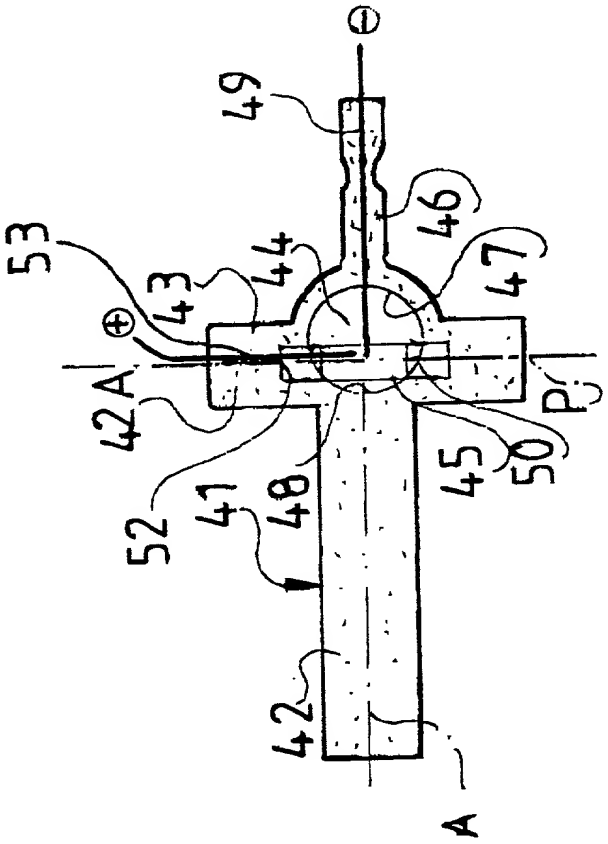

Fig10

PATENT APPLICATION

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of	:	William John BAILLIE-HAMILTON
Serial no.	:	09/171,583
Filed	:	with an effective filing date of April 23, 1997
For	:	LIGHT EMITTING DEVICE AND ARRAYS THEREOF
Docket	:	ROCKCO P39AUS

The Commissioner of Patents and Trademarks
Washington, D.C. 20231

VERIFIED STATEMENT (DECLARATION) CLAIMING SMALL ENTITY STATUS (37 CFR 1.9(c-f) and 1.27(b-d))

With respect to the invention described in

- ☐ the specification filed herewith.
- ■ application serial no. 09/171,583 filed October 21, 1998.
- ☐ patent no. issued .

I. IDENTIFICATION OF DECLARANT AND RIGHTS AS A SMALL ENTITY

I hereby declare that I am

(a) Independent Inventor

■ a below named independent inventor and that I qualify as an independent inventor as defined in 37 CFR 1.9(c) for purposes of paying reduced fees under Section 41(a) and (b) of Title 35, United States Code to the Patent and Trademark Office.

(b) Non-Inventor Supporting a Claim By Another

☐ making this verified statement to support a claim by for a small entity status for purposes of paying reduced fees under Section 41(a) and (b) of Title 35, United States Code and I hereby declare that I would qualify as an independent inventor as defined in 37 CFR 1.9(c) for purposes of paying reduced fees under 41(a) and (b) of Title 35, United States Code, if I had made the above identified invention.

(c) Small Business Concern

☐ the owner of the small business concern identified below:
☐ an official of the small business concern empowered to act on behalf of the concern identified below:

NAME OF CONCERN _____
ADDRESS OF CONCERN _____

and that the above identified small business concern qualifies as a small business concern as defined in 13 CFR 121.3-18, and reproduced in 37 CFR 1.9(d), for purposes of paying reduced fees under Section 41(a) and (b) of the Title 35, United States Code, in that the number of employees of the concern, including those of its affiliates, does not exceed 500 persons. For purposes of this statement, (1) the number of employees of the business concern is the average over the previous fiscal year of the concern of the persons employed on a full-time, part-time or temporary basis during each of the pay periods of the fiscal year, and (2) concerns are affiliates of each other when either, directly or indirectly, one concern controls or has the power to control the other, or a third party or parties controls or has the power to control both.

(d) Non-Profit Organization

☐ an official empowered to act on behalf of the non-profit organization identified below:

NAME OF ORGANIZATION_____

ADDRESS OF ORGANIZATION_____

_____

_____

TYPE OF ORGANIZATION

☐ UNIVERSITY OR OTHER INSTITUTION OF HIGHER EDUCATION

☐ TAX EXEMPT UNDER INTERNAL REVENUE SERVICE CODE (26 USC 501(a) AND 501(c)(3))

☐ NON-PROFIT SCIENTIFIC OR EDUCATIONAL UNDER STATUTE OF STATE OF THE UNITED STATES OF AMERICA
(NAME OF STATE_____)
(CITATION OF STATUTE_____)

☐ WOULD QUALIFY AS TAX EXEMPT UNDER INTERNAL REVENUE SERVICE CODE (26 USC 501(A) AND 501(C)(3)) IF LOCATED IN THE UNITED STATES OF AMERICA

☐ WOULD QUALIFY AS NON-PROFIT SCIENTIFIC OR EDUCATIONAL UNDER STATUTE OF STATE OF THE UNITED STATES OF AMERICA IF LOCATED IN THE UNITED STATES OF AMERICA
(NAME OF STATE_____)
(CITATION OF STATUTE_____)

and that the non-profit organization identified above qualifies as a non-profit organization as defined in 37 CFR 1.9(e) for purposes of paying reduced fees under Section 41(a) and (b) of Title 35, United States Code.

II. OWNERSHIP OF INVENTION BY DECLARANT

I hereby declare that rights under contract or law remain with and/or have been conveyed to the above identified

■ person (item (a) or (b) above)	☐ concern (item (c) above)	☐ organization (item (d) above)

EXCEPT, that if the rights held are not exclusive, each individual, concern or organization having rights to the invention is listed below* and no rights to the invention are held (1) by any person who could not be classified as an independent inventor under 37 CFR 1.9(c) if that person had made the invention, (2) any concern which would not qualify as a small business concern under 37 CFR 1.9(d) or (3) a non-profit organization under 37 CFR 1.9(e).

■ no such person, concern, or organization

☐ person, concerns or organizations listed below*

**NOTE: Separate verified statements are required from each named person, concern or organization having rights to the invention averring to their status as small entities. (37 CFR 1.27)*

FULL NAME_____

ADDRESS_____

_____

☐ INDIVIDUAL ☐ SMALL BUSINESS CONCERN ☐ NON-PROFIT ORGANIZATION

FULL NAME_____

ADDRESS_____

_____

☐ INDIVIDUAL ☐ SMALL BUSINESS CONCERN ☐ NON-PROFIT ORGANIZATION

III. ACKNOWLEDGMENT OF DUTY TO NOTIFY PTO OR STATUS CHANGE

I acknowledge the duty to file, in this application or patent, notification of any change in status resulting in loss of entitlement to small entity status prior to paying, or at the time of paying, the earliest of the issue fee or any maintenance fee due after the date on which status as a small entity is no longer appropriate. (37 CFR 1.28(b))

IV. DECLARATION

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application, any patent issuing hereon, or any patent to which this verified statement is directed.

V. SIGNATURES COMPLETE ONLY (e) or (f) BELOW

(e)

NOTE: All inventors must sign the verified statement

JOHN
William BAILLIE-HAMILTON
Name of Inventor

William John Baillie-Hamilton
Signature of Inventor

19th NOVEMBER 1998
Date

IMPORTANT NOTICE RE

DUTY OF CANDOR AND GOOD FAITH

The Duty of Disclosure requirements of Section 1.56(a), of Title 27 of the Code of Federal Regulations, are as follows:

A duty of candor and good faith toward the Patent and Trademark Office rests on the inventor, on each attorney or agent who prepares or prosecutes the application, and on every other individual who is substantively involved in the preparation or prosecution of the application and who is associated with the inventor, with the assignee or with anyone to whom there is an obligation to assign the application. All such individuals have a duty to disclose to the Patent Office all information they are aware of which is known to be material to patentability of the application. Such information is material where there is a substantial likelihood that a reasonable examiner would consider it important in deciding whether to allow the application to issue as a patent. The duty is commensurate with the degree of involvement in the preparation or prosecution of the application.

By virtue of this regulation, each inventor executing the Declaration for the filing of a patent application acknowledges his/her duty to disclose information of which he/she is aware and which may be material to the examination of the application.

Inherent in this is the duty to disclose any knowledge or belief that the invention:

(a) was ever known or used in the United States of America before his/her invention thereof;

(b) was patented or described in any printed publication in any country before his/her invention thereof or more than one year prior to the actual filing date of the United States patent application;

(c) was in public use or on sale in the United States more than one (1) year prior to the actual filing date of the United States patent application; or

(d) has been patented or made the subject of inventor's certificate issued before the actual filing date of the United States patent application in any country foreign to the United States on an application filed by him/her or his/her legal representative(s) or assign(s) more than twelve (12) months before the actual filing date in the United States.

NOTE: The "Information" concerned includes, but is not limited to, all published applications and patents, including applicant(s) and assignee(s) own, United States or foreign application(s) and patent(s), as well as any other pertinent prior art known, or which becomes known, to the inventor or his/her representative(s). Where English language equivalents of foreign language documents are known, they should be identified and, when possible, copies supplied. Failure to comply with this requirement may result in a patent issued on the application being held invalid even if the known prior art which is not supplied is material to only one claim of that patent.

If there is any doubt concerning whether or not a citation is "material" to patentability of the application, it is better to err on the side of safety and disclose such art to the United States Patent Office.

ROCKCO P39AUS

COMBINED DECLARATION AND POWER OF ATTORNEY

(Original, Design, National Stage of PCT, Supplemental)

As a below named inventor, I hereby declare that:

TYPE OF DECLARATION

This declaration is of the following type: (check one applicable item below)

- ☐ original
- ☐ design
- ☐ supplemental
- ■ National Stage of PCT
- ☐ divisional (see added page)

INVENTORSHIP IDENTIFICATION

My residence, post office address and citizenship are as stated below next to my name. I/We believe that the named inventor or inventors listed below is/are the original and first inventor or inventors of the subject matter which is claimed and for which a patent is sought on the invention entitled:

TITLE OF INVENTION

LIGHT EMITTING DEVICE AND ARRAYS THEREOF

SPECIFICATION IDENTIFICATION

The specification of which: (complete (a), (b) or (c))

(a) ☐ is attached hereto.

(b) ☐ was filed on _with an effective filing date of_ as
☐ Serial No. _ or
☐ Express Mail No. ____ as Serial No. (not yet known) and was amended on ___ __(if applicable).

(c) ■ was described and claimed in PCT International Application No. PCT/GB97/01121 filed on 23 April 1997 and as amended under PCT Article 19 on _____ (if any).

POWER OF ATTORNEY

As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith. (list name(s) and registration number(s))

Anthony G. M. Davis Registration No. 27,868
Michael J. Bujold Registration No. 32,018

☐ Attached as part of this Declaration and Power of Attorney is the authorization of the above-named attorney(s) to accept and follow instructions from my representative(s).

Send Correspondence to:	Direct Telephone Calls to:
Davis and Bujold **Fourth Floor** **500 N. Commercial Street** **Manchester, NH 03101**	(603) 624-9220 Direct Telefaxes to: (603) 624-9229

ACKNOWLEDGMENT OF REVIEW OF PAPERS AND DUTY OF CANDOR

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose to the United States Patent Office all information which is known to be material to patentability of this application as defined in § 1.56 of Title 37 of the Code of Federal Regulations.

PRIORITY CLAIM

I hereby claim foreign priority benefits under Title 35, United States Code, § 119 of any foreign application(s) for patent or inventor's certificate or of any PCT international application(s) designating at least one country other than the United States of America listed below and have also identified below any foreign application(s) for patent or inventor's certificate or any PCT international application(s) designating at least one country other than the United States of America filed by me on the same subject matter having a filing date before that of the application(s) of which priority is claimed.

EARLIEST FOREIGN APPLICATION(S), IF ANY FILED WITHIN 12 MONTHS (6 MONTHS FOR DESIGN) PRIOR TO THIS U.S. APPLICATION

COUNTRY	APPLICATION NO.	DATE OF FILING (day,month,year)	PRIORITY CLAIMED UNDER 37 USC 119
Great Britain	9608381.1	23 April 1996	■YES □NO
Great Britain	9704423.4	4 March 1997	■YES □NO
Great Britain	9706862.1	4 April 1997	■YES □NO
			□YES □NO
			□YES □NO

ALL FOREIGN APPLICATION(S), IF ANY FILED MORE THAN 12 MONTHS (6 MONTHS FOR DESIGN) PRIOR TO THIS U.S. APPLICATION

DECLARATION

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

1-00 Full name of **sole** or first joint inventor: ~~John~~ William BAILLIE-HAMILTON

Inventor's signature: William John Baillie-Hamilton. Date 19th NOVEMBER 1998

Residence: Cardiff Business Technology Centre, Senghenydd Road, Cardiff CF2 4AY GREAT BRITAIN GB

Post Office Address: Same as above Country of Citizenship: GREAT BRITAIN